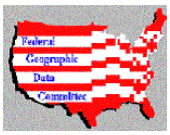
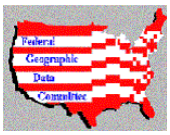


FEDERAL GEOGRAPHIC DATA COMMITTEE

Civil Imagery and Remote Sensing Task Force



Report to the Administration:

Value of Civil Imagery and Remote Sensing

DRAFT for Agency Review

1. Introduction

The U.S. Federal civil agencies[1] recognize the pressing need for a national strategy to promote more efficient collaboration in acquiring, using and distributing civil imagery[2] and in sharing remote sensing capabilities. The civil agencies each use imagery and data regularly to derive information, prepare products for critical national decisions and services, and work closely with state and local governments. In order to promote cost-effective use of satellite-based and airborne imagery and data, the civil agencies require the authority, administration, and budget to continuously coordinate the acquisition and distribution for their individual and collective imagery needs. As a key step toward a national civil imagery strategy, this report presents an overview of the value and enabling role of remote sensing data and imagery to serve the broad range of civil agency mandates.

Imagery and remote sensing systems provide spatial information promptly, efficiently, and in useful formats. In many cases, critical information would not be accessible from other means. In addition, remote sensing can provide mapping and monitoring of locations around the Earth that are difficult, expensive or dangerous to access. For example, imagery assists in determining the direction and movement of wildfires, the yield of foreign wheat crops, the extent of floodplains or floodwaters, and the status of transportation systems. Imagery is regularly used to update base layers of map information that enable rapid response to disaster events and expedite change detection for a wide range of natural resource management applications. Individual agencies often require imagery and data of different characteristics for their unique missions.

Section 2 of this report describes key roles of imagery and remotely sensed data for missions that are vital to Federal agencies. Section 3 describes an organizing model to collect and apply geographic data to support decision-making. Sections 4 and 5 identify some historical factors and future considerations that a national imagery strategy would need to address. Sections 6, 7, and 8 describe key reports, near-term trends, and recommendations.

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[1] The Federal Geographic Data Committee represents 17 Federal agency members (www.fgdc.gov).

[2] Civil imagery refers to both commercial and public sector sources.

2. Value Proposition

Decision makers have many types of information available to them. In 1998, the National Academy of Public Administration reported that $3.56 trillion of U.S. economic activity is directly related to geographic information. The geographic nature of remote sensing data and imagery lend themselves to human's natural, cognitive abilities to detect and interpret pattern, colors, and shapes. Imagery is an inherently rich source of geographic detail that becomes even more valuable when referenced to a geographic coordinate system. Geographic data and information is a critical part of many government functions.

To better understand the uses of imagery within Federal agencies, the Federal Geographic Data Committee (FGDC) conducted a survey to determine the business applications and supporting requirements for remotely sensed data. The survey identified 82 specific applications ranging from agriculture assessments and transportation safety to water quality monitoring, and profiled the requirements for the FGDC-defined seven framework data layers (Geodetic Control, Elevation, Ortho Imagery, Hydrography, Transportation, Cadastral, and Government Units). Appendix A summarizes the survey in terms of framework data layer needs, categories of business applications, and the characteristics of required imagery. The following are examples of some of the major national programs that rely on imagery:

Agency	Program	Coverage
USGS	National Map Program	United States
USDA	Global Crop Assessment Program	Global
	Forest Fire Monitoring	Global
Census Bureau	TIGER Program	United States
ACOE	Levee Maintenance Program	United States Waterways
NOAA	National Shoreline Mapping Program	United States Shoreline
	Coral Reef Mapping Program	United States Islands
	Weather Forecasting	Global
FEMA	Flood Map Modernization Program	United States
	HAZUS Risk Assessment Model	United States
DOT	Transportation Corridor Planning, Infrastructure Inventory and Management	United States
FAA	Safe Flight 21 Program & Aeronautical Charting Program	United States
NASA	Aviation Safety Program	Global
	Solid Earth and Natural Hazards	Global
	Global Climate Change	Global
FGDC	National Spatial Data Infrastructure	United States
USGCRP	Global Change Research	Global

To illustrate the value of imagery and remote sensing to the nation, this report presents imagery applications within the context of seven categories that represent key societal issues:

- Transportation
- Energy
- Agriculture management
- Natural resources management
- Environment
- Science and research
- Emergency management and homeland defense

2.1 Transportation

Increasing trends in population growth and frequency of travel are stressing the capacity of the current transportation infrastructure. The Department of Transportation (DOT) has recognized the importance of investing in the application of advanced technologies, such as automation, communication and Intelligent Transportation Systems, to improve the efficiency and increase the capacity of transportation systems. Current and accurate geographic data can be provided by remote sensing systems and support applications that contribute to multi-modal transportation system for moving people and freight. Geographic data for Synthetic Vision Systems in aircraft and air traffic control facilities alone, for example, are estimated to result in a $2B savings per year for just ten airports in the United States based on a cost/benefit study conducted by the NASA Aviation Safety Program[3]. Application of imageries for snow hazard monitoring and winter weather maintenance services, for example, is expected to save several hundred lives and several million dollars of highway maintenance cost annually for transportation agencies.

Representative uses of remote sensing for transportation include the ability to:

- Locate and chart low-altitude hazards (e.g. power lines and obstructions), which pose a serious threat to timely rescue, fire-fighting, military, and rotor wing aircraft.

- Compile and maintain aeronautical charts by identifying critical features such as navigation landmarks (e.g. roads, railroads, coastlines, water features, unique buildings, city outlines, vegetation, golf courses and emergency landing strips).

- Help track unusual meteorological flight hazards (e.g. smoke from forest fires) that create threats to navigation safety.

- Develop high accuracy terrain databases that support Terrain Awareness Warning Systems and Enhanced Ground Proximity Warning Systems used to reduce Controlled Flight Into Terrain aviation accidents.

[3] Hemm, Robert V. "*Benefit Estimates of Synthetic Vision Technology*," July 2000, NASA LaRC.

- Develop high accuracy airport map databases which will soon be used by Air Traffic Controllers and Flight Crews to reduce runway incursions and related accidents as well as increasing airline traffic flow and relieving airport congestion.

- Develop cost effective environmental and transportation services and achieve cost effective corridor planning to relieve congestion around urban areas.

- Provide new approaches for smarter and cheaper ways of managing transportation infrastructure assets, operation and inspection.

- Deploy new tools for regional traffic flow management including heavy vehicles flow and extend ITS[4] technology reach to regional scale.

- Locate transportation hazards and improve emergency response to accidents and disaster recovery operations.

- Support the global network of detecting and tracking airborne products of explosive volcanic eruptions. Even very minor concentrations of volcanic ash can cause critical jet engine damage.

- Update information that the military will require for Combat Air Patrols within the United States as a result of homeland security.

2.2 Energy

Remote sensing contributes many unique capabilities to the energy industry. Information acquired from aerial photographs and multispectral images offers cost effective means for investigating new energy sources and for mineral exploration. Other applications of remotely sensing of land, oceans, and atmosphere contribute benefits to the energy industry which include:

- Improved thunderstorm forecasts save utility companies $200K/yr in reduced outages[5].

- Improved qualitative precipitation forecasts are needed to optimize the water resource for hydroelectric power generation, potentially saving $320,000/yr nationwide.

- Increasing the accuracy of 30 hour weather forecasts would enable $1B per year in consumer savings as a result of increasing the accuracy of municipal

[4] Intelligent Transportation Systems

[5] "*National Need, Vision & Interagency Plan for FY 2000 – 2006*," The U.S. Weather Research Program: http://mrd3.nssl.ucar.edu/USWRP/USWRP_Vision.html.

procurements of energy to supply heating and cooling for cities across the country.

- Detection of geothermal activity as possible new energy sources. Geothermal energy is obtained from subsurface reservoirs of steam and hot water. Most of this steam and hot water generates electricity.

- Detection of oil film. The National Research Council (NRC) estimates that the amount of oil that enters the world's oceans annually totals 3.24 metric tons. Oil film can be detected using ultra-violet, blue and infrared bands from multispectral imagery.

- Use of Landsat images to detect reserves of coal, oil shale and tar sands in the United States.

- Use of thermal sensors to detect heat emissions from buildings and transformers.

2.3 Agriculture Management

Historically, the U.S. Department of Agriculture (USDA) has made use of remotely sensed data since the Great Depression. Today, USDA and others are using remotely sensed data to direct multi-billion dollar farm programs per year and to forecast global commodity production related to billions of dollars in trade and food aid. Farm managers are now beginning to exploit near real-time remotely sensed data to manage inputs and adjust crop types in an increasingly competitive agriculture environment. Specific agriculture management applications using remotely sensed data include, but are not limited to:

- Continuous monitoring of domestic and international commodity conditions and the estimation of commodity production. Thousands of Landsat scenes, tens of thousands of AVHRR LAC [footnote tech. acronym] images, and hundreds of domestic and global image composites from low resolution sensors are used each year to monitor crop conditions and create production estimates. The Office of Management and Budget (OMB) use domestic and international production estimates in calculating three of their Principle Federal Economic Indicators. These analyses directly impact food security, domestic and international planting decisions, trade conditions and commodity prices.

- Quantify the impact of natural disasters on domestic and international agricultural production. This analysis directly affects domestic and international assistance.

- Helping farmers to determine where and when to apply fertilizer, herbicides and pesticides, and to identify portions of their field in need of irrigation. and the early prediction of yield and harvest quality. This analysis can enable farmers to optimize factors associated with production thus minimizing impacts to environment and maximizing profits.

- Effectively and fairly manage billions of dollars in agriculture programs by providing objective, unbiased observations of crop condition, type, and area. Remotely sensed data are used for compliance activities. Such analysis helps limit fraud, waste, and abuse of farm program funds.

- Predict areas of high risk for livestock disease and other food contamination around the globe.

2.4 Natural Resources Management

This category of land resource management includes a significant range of applications using civil commercial remote sensing. In rangeland management alone, the U.S. Forest Service (USFS) estimates that remote sensing data will save between $6 M and $25 M over a ten-year period. Similar savings and improved performance in other programs remain consistent from fighting forest fires, to managing public lands and parks, to local community planning. Specific implementations of applications using remotely sensed data include, but are not limited to:

- Space-borne sources of imagery are used to produce greenness indices nationwide. These indices reveal drought conditions, plant health and fire hazards.

- Improved temperature and precipitation forecasts lead to greater efficiency in chemical spraying, potentially saving $10-15/acre/application over hundreds of thousands of acres.

- Remote sensing is used to estimate the snow-water equivalence of the winter snow pack. This information aids flood prediction, as well as the prediction of how much water will be available during the year in many parts of the country.

- The use of digital imagery resulted in cost savings of $250,000 by more precisely locating emergency treatments within burned forest areas.

- The use of multiple types of remotely sensed data can provide an alternative to traditional on-the-ground development of range allotment management plans. Savings to the USFS alone are estimated in the range of $6 M to $25 M over the next ten years.

- Imagery from Landsat 7 is being used in a detection and treatment strategy for gypsy moth infestations in Ohio forests. While Ohio isn't the largest timber state, its forests support a $7B/yr industry that brings nearly $1B/yr to some of the state's most economically depressed counties.

- Satellite imagery is used to alert coastal zone managers to harmful algal blooms (red tides) and to determine the direction and extent of such blooms. Algal blooms often pose threats to the shellfish industry and swimmers.

- Accurate elevation information, such as LIDAR, is being used to better manage property development along coastlines. This information is being used to determine setback lines and to help model the potential hazards associated with building homes in close proximity to the ocean.

- Aerial photography and other digital imaging systems are used to monitor changes in the ever-changing shoreline and to keep shoreline maps up to date. This is necessary for navigation, recreation, and multi-purpose resource management.

- Sea surface temperature derived from satellite imagery is used to determine where fishermen must use turtle exclusion devices to reduce the by-catch of sea turtles.

- Airborne and satellite-based synthetic aperture radar systems are used to track oil-spills. This information, coupled with models of ocean current systems, forecasts hazardous spill tracks.

2.5 Environment

Remote sensing supports environmental management at local, regional, and global scales. Remote sensing documents environmental conditions, impacts and change detection. Imagery information provides better understanding of global environmental conditions, pollutant movement, land and coastal processes, and physical oceanography. Imagery applies to environmental planning, modeling, monitoring, management, regulation, enforcement, research, and education.

On a broad scale, imagery provides information such as land use, land cover biomass, vegetation class, habitat change and health, seasonal vegetative changes (fire, harvest, development and disease), global processes, pollutant dynamics, and human interaction. The information contributes to protecting the Earth's biodiversity and unique landscapes, identifying critical areas for conservation, and forecasting potential areas for famine. At very fine scales, imagery provides detailed information on wetland boundaries, shoreline development, urban expansion, and impaired areas like Superfund sites.

2.6 Emergency Management and Homeland Defense

Remote sensing products are used to provide general information about the impacts or potential impacts of disasters. Products derived from remote sensing provide intelligence used in decision-making. Emergency management activities are categorized as planning, mitigation, readiness, response, and recovery. Digital remote sensing data are used to produce elevation models as the base of natural standard flood maps.

Elevation data from photography, LIDAR and IFSAR sources are inputs to flood models in determining potential flood purposes. Models combine hazard data with demographics and the as-built environment to determine vulnerability, risk, and potential loss. After flooding occurs, remote sensing is used to determine and derive actual flood boundaries. These boundaries can an aid to response and recovery activities and help direct and prioritize activities associated with assistance programs.

Remote sensing is used to inventory critical infrastructure, such as power networks, for homeland security purposes. Remote sensing information and intelligence were critically important in the response and recovery efforts following the events of September 11, 2001.

- Accurate elevation information (e.g. LIDAR) is necessary for effective coastal risk assessment and forecasting including real-time inundation mapping, flood forecast mapping, storm-surge modeling, and urban development.

- Large-area, satellite imagery has proven useful in determining the limits of storm inundation for estimating damaged property and for determining where flood maps should be updated.

- Insurance companies use satellite and airborne imagery to estimate costs associated with natural disasters.

- Improved forecasts of tropical weather can reduce delays in offshore oil drilling operations. Improved hurricane track predictions could reduce days of production shutdown. Each shutdown day costs oil and gas companies $15 M.

- Improving tornado warnings through remote sensing has significant effects on both the public and industry. A single tornado warning lasting 40 minutes over 15 miles of track can stop seven trains at a cost of $2000/train/hour. Weather related train derailments cost the industry $1-5M per year.

- The Federal Emergency Management Agency (FEMA) Map Modernization Plan is a major initiative to update flood risk data for the nation and take advantage of new technology. The implementation cost is expected to be over $1B. Over $100 M is required for remotely sensed elevation data to support flood hazard analysis. Implementation of the plan is expected to save over $15B dollars long-term. One of the keys to this plan being cost effective is the increased efficiencies available through advances in remote sensing technology and improved government coordination on this data collection. In addition, FEMA's plan relies on accurate, geo-referenced ortho-imagery from other government sources to provide the base maps needed for its new products.

- Imagery provides a visual intelligence component combined with other geographic data to display the potential results of nuclear, biological, and chemical weapons models. Scenarios have been created using Consequences

Assessments Tool Set (CATS) software package developed for the Defense Threat Reduction Agency and FEMA. For a given hazardous agent, location and environmental factors combined in dispersion models anticipate population impacts and mortality.

2.7 Science and Research

In addition to the operational uses described above, civil agencies conduct and sponsor significant amounts of basic and applied research on global climate change and other important aspects of Earth science. Within the civil community, the U.S. spends more that $2B annually on remote sensing data and data systems. Some researchers utilize remote sensing and imagery from global, regional, and local scales to collect data, monitor conditions, investigate phenomena, and validate measurements. Examples of the use of imagery and remote sensing for scientific research include:

- Resource planning and disaster mitigation rely heavily on weather and climate forecasts. Using remote sensing data, researchers identified warming patterns in the waters off of South America and successfully predicted the 1997-1998 El Nino and the subsequent La Nina.

- Global change research is very dependent upon measurements of atmospheric, oceanic, and terrestrial conditions around the globe. Remote sensing is instrumental in collecting the data to identify and monitor changes.

- Ecological assessments and landscape ecology utilize imagery and remote sensing data at local, regional, and national levels;

- Monitoring the stratospheric ozone concentrations. The ozone is directly related to the amount of ultra-violet radiation that reaches the Earth's surface.

- Monitoring for global warming issues. This ranges from satellites that view the Earth energy balance to measurements of the ocean temperature to estimates of the carbon fixation by both terrestrial and aquatic plants.

2.8 Rapid Access to Imagery

The value of remote sensing data and imagery to support a decision certainly depends upon the availability of that data in the timeframe in which the decision will be made. Data arriving after the decision is made is irrelevant.

In many cases, the data needed to address a given problem comes from several sources. Some data may exist in base layers of data, and the agencies rely on those base layer data being maintained and updated on a regular basis. Other data may be unique and dynamic to a particular time or event. For example, Synthetic Vision Systems in aircraft combines

terrain data with dynamic weather data to support cockpit decisions. Appendices A & B provide characteristics and categories of civil business uses for remote sensing data.

An organized plan to acquire the most appropriate, available data to serve the requirements and timeliness is critical to serving the defined needs. In addition, mechanisms to distribute and transfer data between organizations can be critical to meeting specific deadlines and decision timeframes.

In most cases, established and automated computer-based mechanisms can transfer, combine, and begin analyzing datasets faster than a system with direct-human involvement. Reducing slow or unnecessary hand-offs of data can help the application of remote sensing data and imagery to address the problem and decisions.

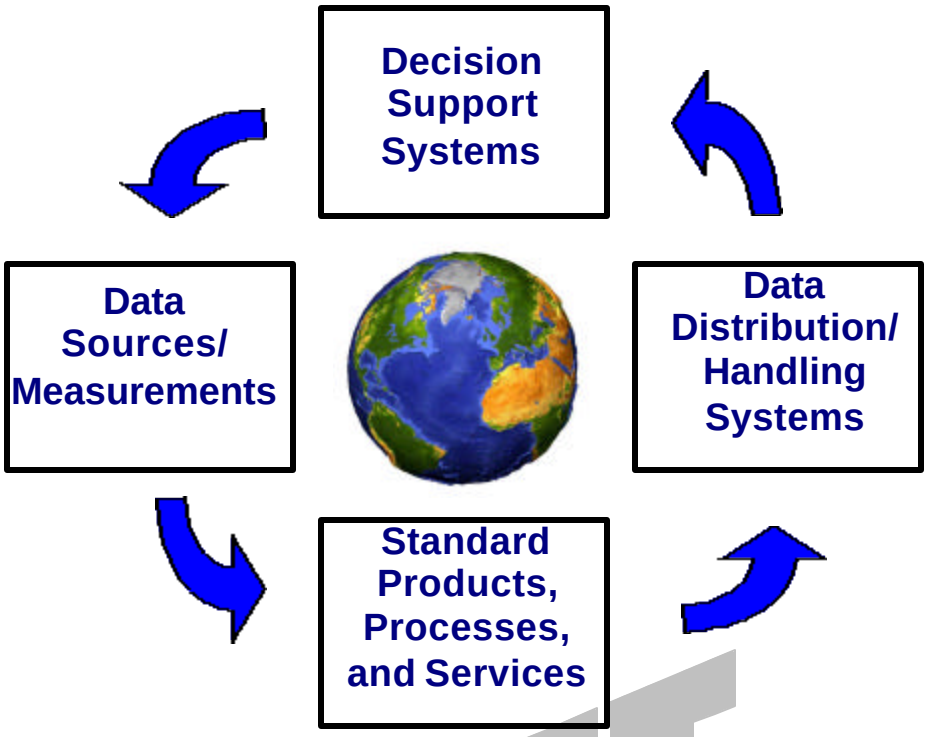
Therefore, a national imagery and remote sensing strategy is extremely valuable for the civil agencies to organize, prepare, and develop networks (physical and organizational) so they can acquire, transfer and process the data in a timely manner.

3.0 Decision Analysis Cycle: Geographic Data & Information

In the examples above, imagery and remote sensing data were shown to support national needs and decision making by Federal civil agencies, officials, and the public. However, the decision phase is just one step in an information path. The diagram below illustrates the flow of data into information products for subsequent delivery for decision-making. In turn, decision makers and practitioners levy new information requirements driving new data and technology development and corresponding distribution and data handling solutions. Timely delivery of relevant information requires that all components of the model be adequately funded, supported, and interoperable. As with other data types, disparate remote sensing needs and systems across civil agencies pose serious challenges to data integration and interoperability that is needed to full advantage of remote sensing technology investments.

This model, or a similar model, provides civil agencies with a common approach for addressing the information lifecycle. A coordinated strategy can help the agencies determine where economies of scale in data collection and management are possible and determine effective ways to coordinate interoperability while allowing each agency to serve its particular mission. For example, agencies may need similar data products that could be distributed on similar systems; but where the use of the data and frequency of the need may be extremely different.

Each component in this information cycle, as well as the strategy for connecting them, need to be addressed in a national civil imagery strategy in order to support and improve decision-making.



4.0 Considerations for a National Civil Imagery Strategy

The following issues and considerations are representative of the topics to address in a national civil imagery strategy. The long-term objective is to develop a national civil imagery strategy that works in tandem with the U.S Department of Defense (DoD) national commercial imagery strategy.

4.1 Civilian and Military Funding and Trade-offs Differ

A strategy to advance more efficient Federal imagery use across the civilian and military civilian sectors has to account for the inherent differences in organization, budget structure, missions, and customers within the two communities.

Imagery support functions in the defense/intelligence community are more centralized and the applications are often more global than in most civil agencies (exceptions to this rule include global climate monitoring and global agricultural assessments). DoD imagery and mapping consolidation was consolidated with the creation of the National Imagery and Mapping Agency (NIMA) in October 1996.

By contrast, civilian programs that utilize imagery and related data products can be found in various organizations including the U.S. Geological Survey (USGS), U.S. Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA), NASA, the Census Bureau, and within components of many other agencies. Civil agencies are required to broadly share and disseminate information to the public as

directed by Executive Order 12906 and OMB Circular A-130. Agencies partner with and serve other Federal agencies, state and local governments and the public.

Commercial imagery providers often sell their data under license agreements to recoup capitalization costs and ensure profitability. These license agreements prohibit, restrict, or at least complicate efforts to provide public access. Traditionally, contracts with conventional aerial survey companies provide full data rights (government owned data) that can be reused and disseminated to maximize the benefits to the users and taxpayers. NIMA's national security mission encourages sharing among Title-50 agencies, but places considerable restrictions on dissemination to other Federal agencies and the public. The USDA Foreign Agricultural Service has a satellite image library through which USDA agencies can gain access to current and archived Landsat, SPOT and AVHRR imagery. This allows the USDA agencies that do not have an imagery budget to exploit to significant imagery resources. Licensed imagery is purchased with an USDA wide license to allow for sharing.

4.2 FGDC and NIMA Framework Layers

The FGDC framework contains seven standardized widely available data layers: geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information. When the orthoimagery layer is current, it provides a map-like image of the Earth's surface. This serves as an excellent source for collecting and updating information contained in various other layers, as a graphic backdrop for many visual reference purposes, and as an alternative to expensive line maps. The widespread availability of framework data layers supports many national and regional applications ranging from national defense to infrastructure and resource management, emergency response, mapping, energy, and transportation. The USGS *National Map* initiative will accelerate the updating of several framework layers and related map information in a seamless fashion (see section 5.1).

NIMA also produces standardized data layers to support the specific needs of the war fighter. The FGDC Framework data layers and the NIMA Foundation data layers are similar in concept; however, each is produced with different standards, scales, and levels of detail appropriate to the uses of the respective communities. Viewing the data layers in the aggregate, there is discussion on the potential synergy between FGDC and NIMA layers.

Both NIMA and FGDC utilize imagery, including commercial imagery, in developing parts of their respective data layers. Currently, the civil agencies rely heavily on aerial photography to develop the FGDC data layers of the US. NIMA uses satellite imagery primarily to create and maintain the Foundation data layers, and NIMA may use increasing amounts of commercial satellite imagery to support its production processes. Cost and licensing are two considerable issues facing the civil community in the use of commercial imagery for the production of FGDC Framework data layers.

5.0 Civil Agencies Lack Explicit Funding to Exploit Existing/Planned Commercial Remote Sensing Capabilities and Existing Civil Satellites

For most civil agencies, remote sensing is only one of many tools needed to fulfill their mission responsibilities. There are rarely funds that have been explicitly appropriated in order to purchase commercial imagery and remote sensing services. More importantly, even where well-defined, funded requirements exist that could be met by commercial sources, there are rarely sufficient funding levels to allow the civil agencies to exploit commercial capabilities. This problem is widespread and may represent the most significant obstacle to implementing a viable relationship with commercial remote sensing companies. Unfortunately, even the funds to purchase satellite imagery from NASA, USGS, and NOAA satellites at the cost of reproduction are not available for many agencies. Civil agencies make due with less than optimal coverage even from civil satellites due to inadequate funding and the lack of an operational focal point for land remote sensing.

Currently, NASA operates satellites and sensors that can meet some civil agency needs for remotely sensed data (e.g. Terra for wildfire detection, tropospheric ozone concentrations, and dust plume monitoring; QuikSCAT for wind profiles and hurricane prediction). However, since these systems were designed to support research, not operations, civil agencies are often obliged to make due using imagery freely available via FTP for purposes that the satellites where not designed for so that they can fill information gaps. This problem is exacerbated when NASA no longer requires a sensor for research purposes, but the civil agencies require the sensor for operational purposes. No lead agency or department has the recognized authority, responsibility, or budget to transition land remote sensing systems to operational programs.

Furthermore, the private sector may have not have a business case to launch a commercial satellite to fill the gap since the civil agencies do not have a budget to purchase the data. This scenario results in a deficit of opportunity for the knowledge that has been painstakingly developed and demonstrated by NASA research to yield long-term operational benefits. This is not the case for NASA research related to oceans and the atmosphere. As the lead operational agency for those remote sensing activities, NOAA funds and operates satellites that monitor oceans and the atmosphere.

Following are examples of programs that could use significant amounts of commercial data sources, but cannot fully exploit commercial sources to meet these requirements due to funding limitations and the lack of an operational focus for land remote sensing.

5.1 *The National Map*

The National Map[6] is a synthesis of base geographic data programs and derivative products including topographic maps of the nation. Working through partnerships with state and local governments and the private sector, the USGS is committed to ensuring

[6] *National Map* documents are available at http://nationalmap.usgs.gov/

the availability of consistent, accurate, and current information to meet a wide range of vital national needs. These needs range from land and resource management and scientific studies to homeland security and infrastructure planning and management. The information content of *The National Map* includes orthorectified imagery, elevation data, selected feature and limited attribute data for transportation, hydrography, boundaries and structures, land cover delineations, and geographic names. The ultimate currentness objective for *The National Map* is to provide data that is sufficiently up-to-date to meet needs such as response to natural hazards and disasters and delivery of time-sensitive government services. Geographic information underpins an increasingly significant share of the nation's economic activity.

The orthorectified imagery content of *The National Map* will be collected and maintained using the most efficient and effective combination of aircraft and satellite-based remote sensing capabilities. This imagery is a vital component of *The National Map* for it is an integrated composite of geographic information that serves as an update source for much of the content defined for the other layers of *The National Map*. This imagery also serves as an archive medium for content and content relationships that will not be otherwise represented in other map layers, but which can be interpreted directly from the image context. The USGS and its partners believe that it will be possible to make substantial improvements in the availability of current orthorectified imagery by sharing the available high resolution photography that is collected for state and local government agencies, directing contracting for additional aerial imagery, and purchasing satellite imagery.

All of the core data content of *The National Map* must be in the public domain to ensure unrestricted access and use opportunities for all sectors, including the general public. As a result, imagery acquisitions for the core layer of *The National Map* will require contractual or licensing agreements that provide for unlimited distribution and reuse.

Achieving current imagery for the entire land area of the United States will require creative partnership agreements and business processes. Repeat procurement of imagery, when required through contracting or direct purchase, will require significant funding. This need is clearly illustrated by the USGS NIMA partnership for orthorectified image and feature information data for the 120 most populous U.S. cities (90 metropolitan areas). The 120 Cities Initiative stems from and directly supports homeland security requirements. During FY02, the USGS will commit at least $4.2M to acquire imagery for 45 of the 90 metropolitan areas. The homeland security requirement is ongoing; NIMA standards relate to imagery that is not more than two years old.

Meeting this requirement in the future will require repeat acquisitions and therefore will require considerable additional funding for this portion of the orthorectified imagery component of *The National Map* (the 90 metropolitan areas cover less than three percent of the total U.S. land area).

By working through partnerships for data acquisition and sharing, including integration of the existing National Digital Orthophoto Program, the USGS will leverage community

resources to creatively fund *The National Map*. However, the combined existing funding from Federal, state, and local agencies, and the commercially viable extent of private sector activities, is insufficient to provide the nation with the imagery infrastructure it so urgently needs to accomplish its domestic agenda.

5.2 Delineation of the National Shoreline.

Accurately delineating the national shoreline is a major challenge facing the U.S. as it Seeks to improve the economic efficiency and competitiveness of U. S. maritime commerce, while reducing risks to life, property, and the coastal environment. Today, ninety-eight percent by weight of the nation's international trade moves through U.S. ports and harbors; fifty percent of these goods are hazardous materials. Thirty percent of America's economic gains over the past six years have resulted from increased exports, and by the year 2020 international trade is expected to increase by 200 percent. However, increased maritime commerce results in increased risks to the coastal environment making marine navigation safety a serious national concern.

One of the most important tools used by mariners for safe navigation is an accurate nautical chart. The precise placement of the shoreline and port facilities provides a critical piece of information included on these charts. This information is almost exclusively derived from remote sources.

In addition to supporting navigation safety, an accurate national shoreline is also key to the economic sustainability and growth of the nation's manufacturing, exportation, coastal development, and insurance industries. A complete up-to-date, consistent, and accurate shoreline will:

- Provide an official U.S. shoreline for a multitude of users.

- Improve electronic charts for navigation. Shoreline depiction is a key element of electronic charts, which if properly used, can significantly increase the safety and efficiency of vessel navigation. Safe navigation also helps protect the environment.

- Provide specialized, large-scale shoreline delineation in harbors for the production of docking charts. Docking charts, when used in conjunction with state-of-the-art electronic navigation systems, allow vessels to dock more safely in low visibility conditions.

- Increase the rate and accuracy of nautical chart revision surveys to keep pace with an accelerated nautical chart publication cycle, and result in more accurate charts for mariners.
- Provide a smooth, consistent transition between the ocean and land interface for more accurate modeling of storm surge, coastal flooding, and pollution trajectory modeling.

- Increase the utility of land and marine geographic information systems to support improved management decision-making.

- Provide for more accurate environmental analysis and monitoring (e.g., monitoring marshlands, wetlands, pollution, and sea level rise; studying coral or aquatic vegetation growth/reduction rates).

To date, NOAA has never mapped one-third of the U.S. shoreline. Of the portion that has been mapped, one-quarter was mapped prior to 1970. Less than 10 percent of the shoreline has been produced digitally. At the present rate of progress, it will take 50 years to accurately compile the entire U.S. shoreline. A re-survey cycle of between five and ten years is necessary to ensure that dynamic changes in the shoreline morphology are accurately captured. This lack of ability to keep pace with mission requirements is not the result of a lack of capability in the commercial sector to meet NOAA's needs. NOAA's inability to employ commercial remote sensing sources to meet its needs is almost entirely resource constrained.

5.3 National Aerial Photography & National Digital Orthophoto Programs

Civilian programs that provide national coverage of standardized imagery have been greatly diminished in recent years. This coverage is essential to support national mapping, environmental, and resource management programs.

The National Aerial Photography Program (NAPP) began in 1988 with an initial goal of acquiring 1:40,000 aerial photography of the conterminous states every five to seven years. The program eliminated duplicate aerial photography acquisition efforts. Scans of NAPP film serve as the primary source for creating rectified images called Digital Orthophoto Quadrangles (DOQs) for the National Digital Orthophoto Program (NDOP). DOQs now cover almost the entire conterminous U.S. and serve a myriad of resource, planning and land management activities.

Both the NAPP and the NDOP are examples of the "best practices" for national coordination of acquisition, management and dissemination of consistent remotely sensed products creating national standards. Cost-shares partners include several civil agencies as well as state and local governments. Unfortunately, the NDOP program is failing because of insufficient Federal funding for NAPP imagery set to be refreshed at a 7-year cycle.

The result is that Federal, state, and local NAPP cooperators are forced to acquire their own imagery at a higher cost rather than waiting for the availability of cooperative funding. When agencies obtain their own imagery, there is little incentive to adhere to a national imagery specification for scale, format or tiling strategy, as provided by the NAPP.

A related problem is that NAPP specifications have not kept pace with the higher resolution needs of some state and local governments. Multiple independent imagery

projects result in localized non-standard data sets that are difficult to locate and use, further perpetuating duplication and higher cost and hindering key programs, such as NDOP or hydrologic and transportation applications.

5.4 FEMA's Flood Mapping Program

In recent years, funding for the Flood Mapping Program has not met the demand for new maps. In the period from 1982 (when the initial effort of detailed mapping was completed) through 1999, FEMA produced approximately 2,100 panels each year through the FEMA-Funded Flood Data Update Program. During that same period, a backlog of 20,500 map panels with outdated flood data built up. Detailed elevation data, which can be obtained using remote sensing, often make up thirty percent of the cost for analyzing flood risks. Frequently the high cost of obtaining this data is the reason that this backlog continues to grow.

Fortunately, in the current budget proposal for FY03, a major increase in funding is proposed for Flood Map Modernization. IF this level of funding is sustained over several years, it will enable FEMA to obtain the remote sensing data needed to update and modernize the flood maps. However, the Map Modernization plan expects to rely on up-to-date digital orthophotos for accurate base maps. If the NDOP is not able to provide this imagery, the Map Modernization plan will face increased costs to obtain suitable base maps.

5.6 Farm Service Agency's Farm Records and Compliance Programs

Since the 1930s, USDA has used aerial photography to record farm ownership and administer farm programs. These scaled hardcopy photographic enlargements, maintained with pen and pencils, provide the basis for billions of dollars of farm program payments. At current funding levels, the process of transforming these records into digital layers that can be shared and maintained in a GIS will take many years to complete. As the farm records become digital, the Farm Service Agency's (FSA) yearly 35mm aerial photography required for compliance must be converted to GIS-ready digital images. When looking at acquisition costs per square mile, the current 35mm program cost between $3-5 while commercial satellite imagery costs over $40 per square mile.

5.7 Foreign Agricultural Service's Global Crop Condition Assessment Program

USDA's Foreign Agricultural Service (FAS) has used satellite imagery to monitor global crop conditions for almost two decades and has been the largest production user of Landsat imagery. However, the areas where Landsat has been acquired has been far from global due to funding constraints. Even without funding constraints, Landsat 7 was not designed to acquire the data volume that FAS requires. No operational land remote sensing satellites exist or are planned that would meet the FAS requirements. In order to be operational, FAS must use NOAA satellites that where not designed for agricultural

monitoring and NASA research missions.

6.0 Related Activities and Studies

6.1 Geospatial One-Stop

The FGDC is leading the "Geospatial One-Stop" project to help build common framework standards. Framework datasets will be easily accessible via the National Spatial Data Infrastructure Clearinghouse network, which will provide "one-stop" access to FGDC-compliant data. The framework benefits all spatial data customers (including Federal, state, local, and other governments, as well as private citizens) by providing a common, consistent source of geospatial data. This initiative is one of the 23 E-government initiatives selected by the President's Management Council. It will significantly enhance the implementation of e-government by enabling geospatial data to be more accessible and usable.

6.2 Congressional Research Service Report on Remote Sensing Use

Future decisions on how to best coordinate and advance the imagery activities of Federal agencies is informed by a variety of studies, such as the Congressional Research Service's (CRS) survey of remote sensing data and technology use by 20 Federal non-military agencies[7] Congress commissioned the Report in order to better understand Federal use of remote sensing and issues that arise in obtaining and applying the technology and data.

The CRS report states that the most frequent remote sensing data application was for environmental and conservation purposes, with ten agencies reporting extensive or moderate use. Seven agencies reported extensive to moderate use of remote sensing for early warning, mitigation, monitoring, and studying the impact from natural disasters. Other uses include basic and applied research, mapping activities, monitoring and verifying compliance with laws and treaties, agricultural activities, and transportation and shipping.

Participating agencies cited many concerns, which can be categorized as availability, access, and effective use of remote sensing data and technology. Ten agencies reported availability concerns, referring to the problems and difficulties agencies experienced in getting the data needed to carry out specific tasks and missions. Twelve agencies reported access concerns, referring to the general problems associated in using data. Nine of these agencies cited cost and licensing concerns with commercial data and value-added products and analysis. Nine agencies reported concerns over their capacity to use effectively and fully exploit remote sensing data and technology, mostly due to a shortage of trained personnel within the agencies to analyze and interpret data.

[7] *Assessment of Remote Sensing Data Use by Civilian Federal Agencies*, Senate Governmental Affairs Subcommittee on International Security, Proliferation, and Federal Services and the Congressional Research Service, December 2001.

7.0 Near Term Trends

Over the next few years the concentration on homeland security and rapidly changing technology should fuel increased interest in remote sensing. Even so, the availability of trained personnel to use the data, the costs and complexities of using the data, and the issues of licensing are challenges to be overcome if the benefits of the technology are to be fully recognized. To some extent, computer technologies and software are making remote sensing data more useable a broader array of users.

The urgency of modernizing homeland security should also foster greater cooperation across the civil agencies as well as between the civil and defense communities. Ideally, all agencies with responsibilities for certain aspects of homeland security will come together to form a more coordinated approach to remote sensing technologies and policies. In terms of sources, multi-spectral sensor sources will increase dramatically, as will the availability of hyper-spectral and eventually ultra-spectral sensors.

8.0 Recommendations

This report has illustrated that there are pressing societal issues that are being addressed by Federal agencies using imagery remote sensing technologies. However, the full benefit of this technology is not being realized because federal remote sensing activities are often under-funded and hindered by insufficient interagency coordination and leadership. In some cases modest budget increases and/or administrative changes could extend agency capabilities to efficiently service missions needs within other agencies. In other cases, the faster, better, cheaper, operational capabilities that remote sensing can provide are not being achieved because basic remote sensing research is not being transitioned to operations to address the real world problems facing the civil community. To address these issues, the FGDC Civil Imagery and Remote Sensing Task Force recommends:

1. That the Administration commission the National Academy of Public Administration (NAPA) to perform the proposed study: "Creating a Robust National Civil Imagery Capability" (Appendix B). The study is designed to promote more efficient government wide collaboration in acquiring, using and distributing civil imagery[8] and in sharing remote sensing capabilities. NAPA findings are needed by late Fall 2002 to be useful to the Task Force and the Administration in completing a national strategy, accessing policy options, and formulating a 2005 budget initiative during the spring of 2003.

2. That the FGDC extend the operation of the Federal Civil Imagery and Remote Sensing Task Force under a Charter revised to reflect its role in addressing strategic and policy related matters critical to the use of civil imagery in federal programs.

[8] Civil imagery refers to both commercial and public sector sources.

Appendix A – August 2001 FGDC Survey

In August 2001, the FDGC conducted a rapid survey of 15 Federal civil agencies and offices to determine their business applications and supporting information requirements. Agencies identified critical high-level business functions and which of the seven National Spatial Data Infrastructure (NSDI) framework data layers supported the function. The seven framework data layers are as follows:

- Geodetic Control
- Elevation
- Hydrography
- Cadastral
- Orthoimagery
- Transportation
- Governmental Units

Collectively, the Federal agencies identified 82 business functions. The following figures characterize the Federal agencies use of the NSDI data layers for their functions:

NSDI Data Layers

Percent of Business Applications Using the NSDI Framework Data Layer

Geodetic Control	51%
Orthoimagery	77%
Elevation	62%
Transportation	67%
Hydrography	65%
Governmental Units	50%
Cadastral	33%

NSDI Data Layers

Percent of Business Applications Using Multiple NSDI Data Layers

5 or more layers	38%
3 or 4 layers	40%
2 or fewer layers	22%

Using one or more layers potentially derived from Imagery or Remotely Sensed Data 90%

The business functions represented the following categories of activity:

- Long Term Monitoring
  A. Requirement for Daily/hourly observations:
    1. Weather
    2. Fire
    3. Hazards
    4. Traffic
  B. Requirement for Weekly/bi-weekly observations:
    1. Agricultural Monitoring
  C. Requirement for Seasonal Observations:
    1. Global Climate Change
  D. Requirement for one or two observations per year at specific times.
    1. Program Compliance Activities
    2. Environmental/Resource inventories

- Disaster Response Activities
  A. Hourly/Daily/Weekly Monitoring
    1. Damage Assessment
      Public Safety
      Property Impacts
      Infrastructure Impacts
      Environment Impacts
      Health Impacts
      Food Security Impacts
    2. Disaster Response

- Long Term State/National/Global Mapping:
  A. Requirement for cloud free imagery, will wait until imagery is available to start project.

Imagery needs supporting the business functions were further characterized according to the geographic extent, frequency of activity, spatial resolution, and timeliness of fulfilling the data request. Several of the trends that emerged are: an emphasis on regional and national applications, higher resolution imagery, either short or long-term requirements, and a diversity of timeframes for repeat coverage.

Characteristics of Business Needs for Imagery

Percent of Business Needs

Areal Extent

Local	15%
Regional	24%
National	55%
Global	6%

Frequency of Activity

Ad Hoc	19%
Daily/Weekly	12%
Monthly/Seasonally	10%
Annual	22%
Multi-annual	36%

Spatial Resolution

Less than 2 meters	58%
2-10 meters	31%
10-30 meters	8%
More than 30 meters	3%

Timeliness/Response

Days	26%
Week-Month	25%
Months	9%
More than 6 months	41%

(Totals greater than 100% due to rounding.)

Appendix B – Draft NAPA Proposal: Creating a Robust National Civil Imagery Capability (Version. 1.0)

To assess civil agency imagery needs, the Federal Geographic Data Committee (FGDC) conducted a survey to determine key Federal business applications for remotely sensed data in August of 2001. The survey identified 82 specific applications ranging from agriculture assessments and transportation safety to water quality monitoring, disaster response, and environmental and natural resource assessment and monitoring. The requirements included a broad range of airborne and satellite sources across the electromagnetic spectrum, but was weighted heavily within the domestic high-resolution arena. Since that time, the FGDC has undertaken an extensive effort to document the value of imagery in addressing key societal interests related to our economy, infrastructure and public safety.

Despite the proven utility and critical need for imagery in Federal programs, many civil agencies lack funding that is explicitly appropriated for purchasing imagery and remote sensing products and services. More importantly, even where funding exists to address well-defined requirements, it is rarely sufficient to allow agencies to exploit commercial capabilities. This problem is widespread and may represent the most single most significant obstacle to implementing a viable relationship with commercial remote sensing companies. In addition, civil agencies have not established a unified approach to identify common airborne and satellite imagery requirements, or cost effectively procure, manage and distribute imagery to efficiently address their mission needs. Finally, no lead agency or multi-agency program office has a clear legislative mandate to plan, administer, and seek the needed funds for satisfying operational requirements and developing a shared infrastructure

To address these problems, the Civil Imagery Task Force of the Federal Geographic Data Committee (FGDC) has requested help from the National Academy of Public Administration (NAPA) to study and recommend leadership, legislative, and budgetary approaches to allow Federal civil agencies to collaborate more effectively in the acquisition, use and distribution of imagery and remote sensing products. The proposed study builds on NAPA's prior work analyzing how federal civilian agencies can improve their access to surveying, mapping, global positioning systems, and other geographic information services. NAPA proposes to analyze the following questions:

1. What are the fundamental operational imagery requirements over the next 5-years and the approximate costs of satisfying these requirements?

2. What alternatives or options are available that might serve as models for agencies to jointly accomplish the following imagery activities:

   a) Define and validate common requirements for imagery products and services

   b) Acquire, procure, and/or license imagery products

c) Manage and disseminate imagery products

d) Share the capacity to analyze and use imagery products

e) Archive, preserve, and provide for future retrieval of imagery products.

3) What management approaches, budgetary options, and possible policy and legislative changes that could provide the funding and institutional structures needed to carry out robust civil agency collaboration and expanded imagery use?

4) What are the most viable opportunities to partner with the DoD, State and local agencies and other NGO's for achieving these goals?

The FGDC asks that the Academy complete this work by December 2002. NAPA estimates that total funding of $250,000 to 300,000 would be needed for this study.

Appendix C – Studies related to the Federal Civil Use of Remote Sensing.

ASPRS Survey
National Academy of Public Administration (NAPA) Study
National Spatial Data Infrastructure (NSDI) Finance Study
National Aeronautics and Space Administration (NASA) Aviation Study
Federal Geographic Data Committee (FGDC) Geospatial One-Stop Study
National Research Council (NRC) Reports
Congressional Research Service (CRS) Report